DEVELOPMENT OF FILTERING SYSTEM FOR THE PRODUCTION OF BIODIESEL FROM USED COOKING OIL

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I declare that this thesis entitled **"DEVELOPMENT OF FILTERING SYSTEM FOR THE PRODUCTION OF BIODIESEL FROM USED COOKING OIL"** is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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Date : 27 November.2006

DEDICATION

Special Dedication of This Grateful Feeling to My...

Beloved mother;
Mrs Kamar binti Zainal Abidin

Loving brother and sister;
Asrul and Afza

Supportive and understanding friends;
Wan Noorlinda Roshana binti Mohd Nawi

For Their Love, Support and Best Wishes.

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ABSTRACT

Biodiesel can be produced from many sources such as rapeseed oil, vegetable oil, used cooking oil and many more. From the point of view price and available capacity used cooking oils (UCO) represent an attractive raw material for the production of methyl esters (ME) known as biodiesel as alternative fuels for diesel engines. The purpose of this study is to develop a filtering system to get a cleaner used cooking oil to produce biodiesel, beside that to study the effect of the base catalyst in producing biodiesel from filtered used cooking oil. The filter is built from polypropylene filter beg, PVC vessel and the base made from wood. Determination of the filtering system effectiveness and the effect of the catalyst is by using gas chromatography (GC) to detect the presence of methyl palmitate that is one of the component in methyl ester. From this result of the experiment the filtering system that had been fabricate can be used to treat the UCO and the exactly amount of catalyst needed is 1.00gram for the react with 250mL UCO and 50mL MeOH.

ABSTRAK

Biodiesel boleh dihasilkan daripada pelbagai sumber contonhnya minyak rapeseed, minyak sayuran, minyak masak terpakai dan lain-lain sumber. Dari segi harga dan quantity minyak masak terpakai boleh menjadi satu bahan mentah yang menarik dalam menghasilkan metil ester juga dikenali sebagai biodiesel yang bertindak sebagai satu bahan baker alternatif untuk kenderaan berenjinkan diesel. Tujuan penyelidikan ini adalah untuk membina satu sistem penapisan minyak masak terpakai untuk menghasilkan minyak masak yang lebih bersih dalam menghasilkan biodiesel di samping itu juga, penyelidikan ini adalah untuk mengkaji kesan pemangkin dalam menghasilkan biodiesel daripada minyak masak terpakai. Penapisan minyak ini dihasilkan dari pada beg penapis jenis polypropylene, bekas PVC dan diletakkan pada papan sebagai tapak sistem penapisan itu. Untuk mengetahui keberkesanan sistem penapisan minyak itu dan kesan pemangkin, Lima sampel dianalisis menggunakan Kromatografi Gas. Keputusan daripada analisis tersebut menunjukkan bahawa sistem penapisan minyak itu boleh digunapakai dan jumlah pemangkin yang digunakan adalah sebanyak 1.00 gram untuk ditindakbalaskan dengan 250 mL UCO and 50 mL MeOH.

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LIST OF SYMBOLS

°C	-	°Celcius
FUCO		Filtered Used Cooking Oil
g	-	gram
GC		Gas Chromotography
L	-	liter
ml	-	mililiter
MPOB		Malaysia Palm Oil Board
NaOH		Sodium Hydroxide
PVC		Poly Vinyl Chloride
UCO		Used Cooking Oil
wt %	-	weight percent

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CHAPTER 1

INTRODUCTION

1.1 Background

Vegetable oils have attracted attention as a potential renewable resource for the production of an alternative for petroleum-based diesel fuel. Various products derived from vegetable oils have been proposed as an alternative fuel for diesel engines, including neat vegetable oil, mixtures of vegetable oil with petroleum diesel fuel, and alcohol esters of vegetable oils. Alcohol esters of vegetable oils appear to be the most promising alternative [1]. Vegetable oils are triglycerides and glycerin esters of fatty acids; alcohol esters of fatty acids have been prepared by the transesterification of the glycerides, wherein linear, monohydroxy alcohols react with vegetable oils in the presence of a catalyst to produce alcohol esters of vegetable oils and glycerin as a by-product. Alcohol ester of vegetable oils when used as an alternative diesel fuel has been identified as a “biodiesel”.

It has been proven when Dr. Rudolf Diesel demonstrated the first diesel engine at the World Exhibition in Paris in 1900. He used 100% peanut oil as fuel. Dr. Diesel originally intended that the diesel engine be fueled by a variety of fuels, including vegetable oil and mineral oil. He promoted the use of vegetable oil as fuel by suggesting that it would greatly benefit the development of agriculture in countries that utilized this potential [2]. The adoption of petroleum-based fuel as the primary fuel for the diesel

engine was an arbitrary decision that was largely influenced by the cheaper costs of petroleum at the time.

The important process in converting used cooking oil (UCO) to biodiesel is transesterification and filtering system. Transesterification is the process of exchanging the alkoxy group of an ester compound by another alcohol. These reactions are often catalyzed by the addition of an acid or base. In producing of biodiesel, transesterification of cooking oil involve reaction of alcohol with oils in presence of base or acidic together with methanol to produce methyl ester and glycerol. Meanwhile filtering system is used to purify the UCO from impurity such as water and unused fatty acids.

In this study, UCO is used as the raw materials due to the significant disposal problem caused by UCO which contributes to the pollution of the environment. The present of methyl esters in vegetable oils are considered a real alternative to liquid fossil fuels. Biodiesel from UCO has a potential to become an alternative energy sources. Conversion of the UCO biodiesel fuel has many environmental advantages and cheaper than petroleum based diesel fuel.

Compositions of UCO are vegetable oil (triglycerides), free fatty acids and water [3]. This research will be focusing on filtering system which is the essential process in the conversion of UCO into biodiesel. The filtration system is important in removing the impurity in UCO. Batch operations will be used instead of the continuous process because there are lots of advantages. Some of the advantages are low in cost, low in control and it also has a greater flexibility compared to other operations.

1.2 Problem Statement

Malaysia is looking for the renewable sources that can be use to substitute the fossil fuel in the future. The fossil fuel sources nowadays are limited and can only last for another 20 to 30 years. Owing to the scarcity of the fossil fuel, the price of petroleum and diesel had increased tremendously over time. Even in Malaysia, where the price of

petroleum and diesels are highly subsidized by the government, it has increase significantly over the years. Recently, the price of petroleum and diesel has increase by 30 cent a liter, the highest increase in the past two years. Table 1.1 shows the increasing price of the petrol and diesel fuel in Malaysia.

Table 1.1: The new price of fuels [4]

FUEL PRICE CHANGE EFFECTIVE FEB 28
(RM/litre)

	Peninsula		*Sabah*		*Sarawak*	
	Before	*After*	*Before*	*After*	*Before*	*After*
• Petrol (premium)	1.62	**1.92**	1.60	**1.90**	1.61	**1.91**
• Diesel	1.281	**1.581**	1.284	**1.584**	1.278	**1.578**
• LPG (per kg)	1.45	**1.75**	1.53	**1.83**	1.53	**1.83**

	Before	*After*
• Petrol (regular) for whole of Malaysia	1.58	**1.88**

In a search for an alternative fuel that can substitute the petrol diesel, there are many sources available that can be used as raw materials to produce fuel. One of them is used cooking oil (UCO) which contributes to the pollution and will harm the food chain that can lead to unhealthy human being. However, the cost to produce biodiesel from UCO is expensive. This is due to the fact that it needs to be treated first to make sure it is free from contaminate.

UCO also contribute to the water pollution. There are many causes for water pollution but two general categories exits. One of them is UCO, those fluids of varying quality flows directly into urban water supplies. UCO is one of the most commonly reported types of water pollution and causes nearly a quarter of all pollution incidents. Careless disposal of oil into drainage system, onto land or to watercourse is not only an offence but can be harmful to river, flora and fauna and other wildlife that uses river as their source of water.

Although oil does break down in water it uses up vast amounts of oxygen in the process, hence removing oxygen that would otherwise remained in the waterways for wildlife. Contaminants can be broadly classified into organic, inorganic, radioactive and acid or base. Water pollution have adversely effect the life through poisonous drinking water, poisonous food animals, unbalanced river and lake ecosystems that can no longer support full biological diversity, deforestation from acid rain, and many more other effects.[5]

1.3 Objective and Scope

The objective of this research is to develop a filtering system to produce biodiesel from UCO with the scope of this research are:-

i. To develop the filtering system to get a cleaner used cooking oil to produce biodiesel.

ii. To study the effect of the catalyst in producing biodiesel from filtered used cooking oil.

1.4 Research Contribution

This research can help in minimizing the environmental impact cause by used cooking oil and unhealthy food chain if the used cooking oil is use to produce animal feed. This research can also be used as a guideline and references in producing a new source of energy from used cooking oils.

1.5 Thesis Layout

This thesis has 5 chapters. Chapter 1 introduces production and history of biodiesel. It is also includes objective, scope and problem statement. Chapter 2 is about literature review which includes the definitions of biodiesel, chemical reaction that happen in producing biodiesel from used cooking oils, and more about filtering system. In Chapter 3, the methodology in designing and developing the filtering system, and also the steps needed to produce biodiesel will be discussed. Chapter 4 will be discussing about the results obtained from the experiment. It includes the efficiency of the filtering system. Lastly Chapter 5 will conclude the thesis and provide recommendations on how to improve the production of biodiesel from UCO.

1.6 Research Schedule

Figure 1.1 shows the Gantt chart used for Industrial Project 2 in doing the experimental and fabrication work for this project. The Gantt chart is important in managing the work schedule in order to ensure that the Industrial Project 2 can be completed on time.

TASK/WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Fabrication work																			
Experimental work																			
Analysis of Collecting Samples																			
Editing First Draft																			
Final Draft 1 Submittion																			
Preparation for Progress Report Presentation																			
Progress Report Presentation																			
Technical Paper Preparation for Seminar 2																			
Seminar 2																			
Editing Final Draft 1																			
Final Draft 2 Submittion																			
Editing Final Draft 2																			
Thesis Submittion																			

Figure 1.1: Gantt chart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, the usage of biodiesel as an alternative fuel has become increasingly important in Malaysia. Although the production and usage of biodiesel is still in its infancy stage, not broadly used and costly, global demand for biodiesel especially from the European countries could lead to palm oil prices going above RM 1,550 per tonne this year, said executive of Malaysian Palm Oil Association (MPOA), M.R. Chandran. [6]. There are many sources to produce biodiesel, one of them is UCO.

2.2 Used Cooking Oil (UCO) as a Raw Materials

Recently, the usage of vegetable oils as biodiesel has become more attractive because of their environmental benefits and the fact that it is made from renewable resources. More than 100 years ago, Rudolph Diesel tested vegetable oil as the fuel for his engine. Vegetable oils have the potential to substitute for a fraction of the petroleum distillates and petroleum based petrochemicals in the near future. Vegetable oil fuels are not now petroleum competitive fuels because they are more expensive than petroleum fuels. However, with the recent increases in petroleum prices and the uncertainties concerning petroleum availability, there is renewed interest in using vegetable oils in diesel engines. The success of rapeseed ethyl ester production would mean that biodiesel

main raw materials would be agriculturally produced, renewable and environmentally friendly.

UCO is generated in large quantities during food preparation especially in the fast food network, large restaurants, dinning room and many more. The oil is then transported to animal feed producers where it is mixed with various animal feeds to go back into the food chain. This phenomenon is unhealthy for human being because it can cause health problems. Figure 2.1 shows the food chain that involves UCO. Human being cook their meals with cooking oil. This oil is not 100% consumed during the process and left as wastages. These wastages (i.e. used cooking oil) largely used in making the animal feeds. These animals are then consumed back by the human being. From the chain human indirectly eat used cooking oil that contains free fatty acids that is not good for health. (Source: Philip Calais (environmental science) &AR Tony Clark (Western Australia Renewable Association Inc))

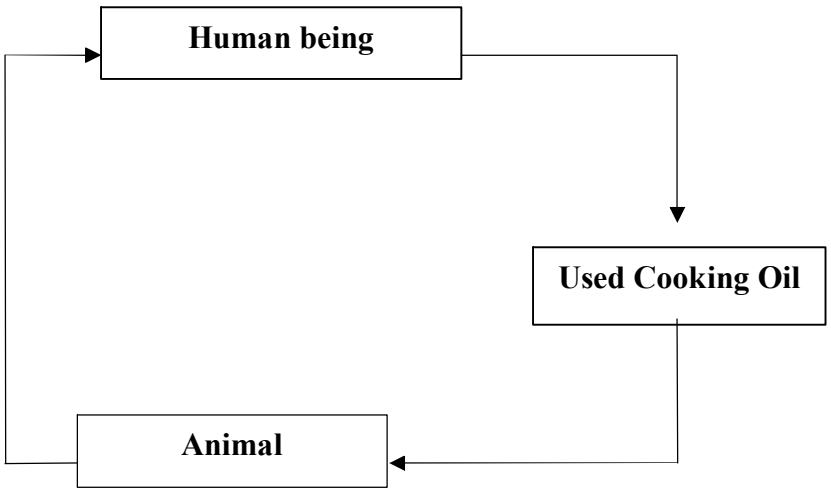

Figure 2.1: The Food Chain that involve used cooking oil

UCO that is kept for a certain period of time will cause three circumstances. These three circumstances are hydrolytic, oxidation and cracking reaction that can take place within the fat. Hydrolytic splitting of triacylglycerols takes place in the presence of

water, which enters the fat together with the fried food. Part of the water quickly evaporates, but a certain part dissolves in the fat and induces its cleavage to give higher fatty acids and glycerol. Oxygen, from the air, dissolved in the fat reacts mainly with unsaturated acylglycerols (AG) resulting in the development of various oxidation products. Saturated and unsaturated aldehydes, ketones, hydrocarbons, lactones, alcohols, acids and esters are produced by the decomposition of hydroperoxides. Hence, it is better to convert UCO into biodiesel rather than became one of the waste pollution. However, in order for UCO can be used as biodiesel, it needs to be filetered first.

2.3 Filtering system

Filtration is a technique used either to remove impurities from an organic solution or to isolate an organic solid. The two types of filtration commonly used in organic chemistry laboratories are gravity filtration and vacuum or suction filtration.

2.3.1 Gravity filtration

Gravity filtration is the method of choice to remove solid impurities from an organic liquid. The "impurity" can be a drying agent or an undesired side product or leftover reactant. Gravity filtration can be used to collect solid product, although generally vacuum filtration is used for this purpose because it is faster. For this system polypropylene filter bag is used as a filter medium.

2.3.2 Polypropylene Filter Bag

Polypropylene is one of those rather versatile polymers out there. It serves double duty, both as a plastic and as a fiber. As a plastic it's used to make things like dishwasher-safe food containers. It is suitable because it doesn't melt below 160^{o}C, or 320^{o}F. Polyethylene, a more common plastic, will anneal at around 100^{o}C, which means

that polyethylene dishes will warp in the dishwasher. As a fiber, polypropylene is used to make indoor-outdoor carpeting, the kind that you always find around swimming pools and miniature golf courses. It works well for outdoor carpet because it is easy to make colored polypropylene, and because polypropylene doesn't absorb water, like nylon does.

Structurally, it's a vinyl polymer, and is similar to polyethylene, only that on every other carbon atom in the backbone chain has a methyl group attached to it. Polypropylene can be made from the monomer propylene by Ziegler-Natta polymerization and by metallocene catalysis polymerization.

Polypropylene filter beg (figure 2.1) is suitable for filtering the cooking oil because it is the most economical way for filtration of highly viscous fluids like oil and for the fluids with higher contaminant level. Since oil is very viscous fluid, it requires large surface area for filtration. It is fabricated using high dirt holding media that provides consistent particle retention. Longer life reduces purchase cost, downtimes due to change outs, and disposal costs. Thus it reduces overall filtration cost compared to cartridge filters. It can be used for filtering lubricants, cooking oil, hydraulic oil, quench oil, jet fuels and others.

Figure 2.2: Polypropylene Filter Bag

Polypropylene filter bag is unique, graduated layering of media starting with a built in pre filter inner layer and progressing to the tighter outer layer. The particles are systematically removed as fluid travels through multiple layers with each individual layer performing a special function. It has the lowest standard deviation of any other filter which means users achieve more consistent results from batch to batch. Equally important, this product presents the ultimate value in high purity filtration.

2.3.3 Theory of the filtering system

Producing biodiesel from UCO is almost similar with the production of biodiesel from pure cooking oil. However, the UCO needs to be filtered first before it can be used as a feedstock. The water content in UCO must be removed to make it free from water. This is the important step that differ the production of biodiesel from pure cooking oil.

Filtering system is essential to remove the presence of particles from the used cooking oil to make sure that the oil is free from impurity. Filtering oil will remove contaminate from used cooking oil. Heating oil will allow quicker filtration but also allow oil components with a higher melt point through the filter [11]

Filtration is the separation of two phases; particulates form an example solid particles or liquid droplets and liquid or gas from a mixture by passing the mixture through a porous medium. Filtration is often referred to as a mechanical separation because the separation is accomplished by physical means. This mean filtration does not preclude chemical or thermal pretreatment. In the filtration system in (Figure 2.2) the porous filtration medium is housed in housing, with flow of liquid in and out. A driving force, usually in the form of a static pressure difference, must be applied to achieve flow through the filter medium. Filtration processes can be separated into two broad categories which must be dealt with separately. These two categories are cake filtration and depth filtration.